COURSE TITLE: FOOD AND INDUSTRIAL MICROBIOLOGY
COURSE NO. - DTM-321: CREDIT HRS-3 (2+1)

FOOD PRESERVATION
ADVANCE NON THERMAL METHODS – PART 2

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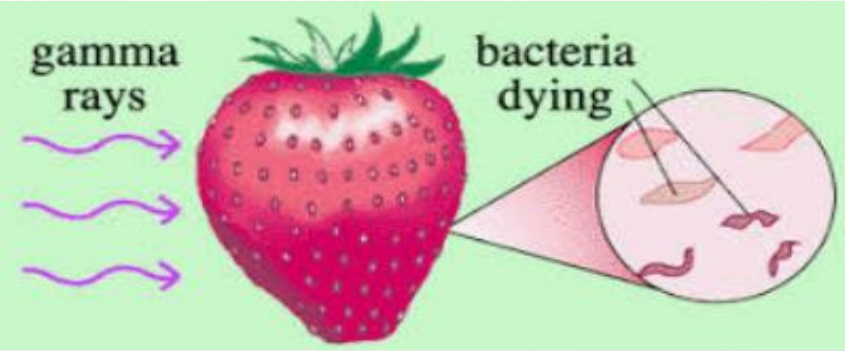

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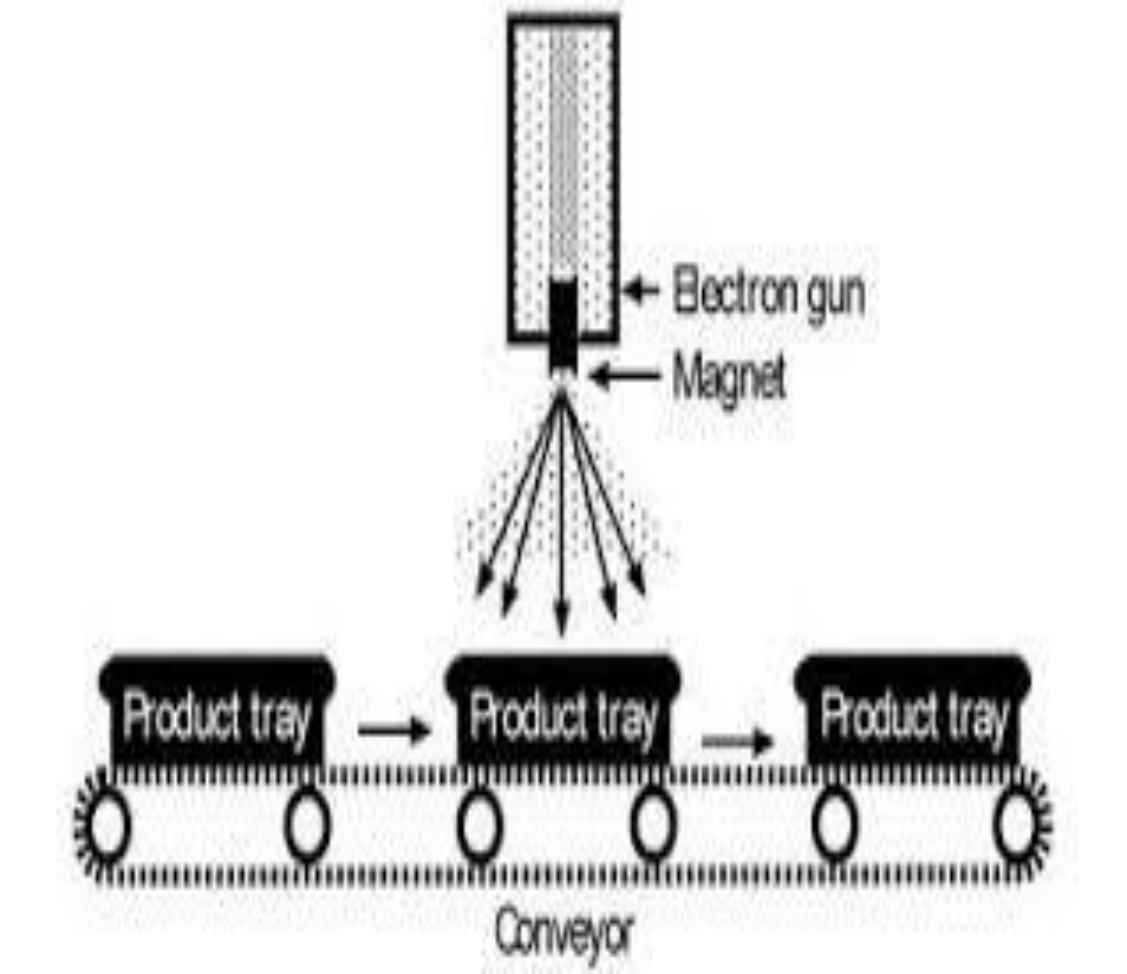
Why new technology of preservation required ?

Intelligent solutions need to be developed for sustainable food and agricultural consumption patterns with global food security. An environment friendly intervention strategy or methods required to develop for global food security which is suitable to protect food products from decay or pests and ultimately resulted in reducing losses and extending shelf life of the product.

NON-THERMAL PROCESS ARE:-

- Ohmic Heating
- Microwave heating
- Pulsed Light Technology
- Pulsed Electric Field
- Infrared heating
- High Pressure Processing
- Ultrasonics
- Oscillating Magnetic Field
- Radio frequency heating
- Irradiation



HIGH PRESSURE PROCESSING (HPP)

- High Pressure Processing is also known as “High Hydrostatic Pressure” or “Ultra High Pressure” processing. HPP uses up to 900 MPa to kill many of the micro organisms found in foods even at room temperature without degrading vitamins, flavor and colour molecules in the process.

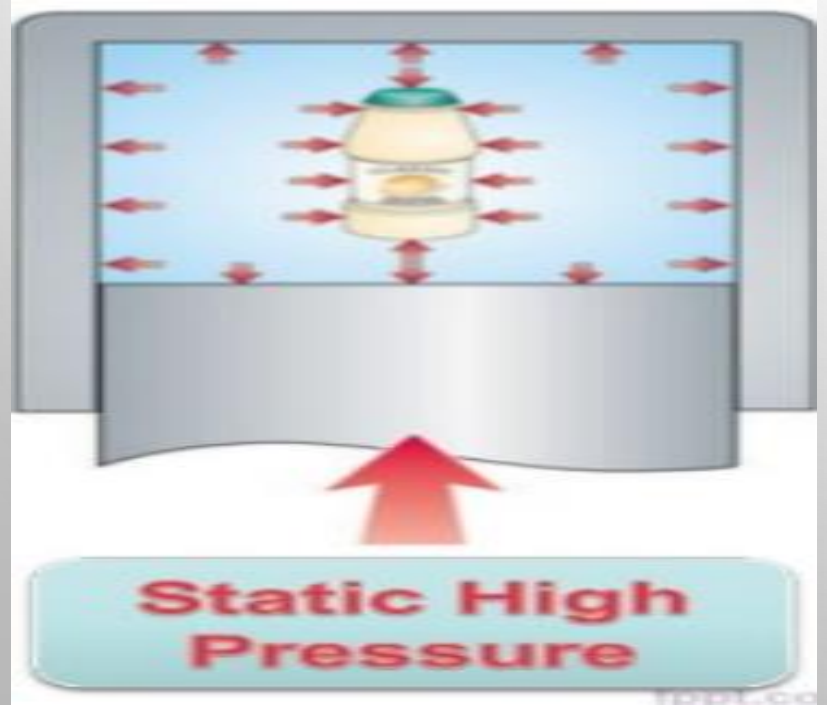
- Food packages are loaded onto the vessel and the top is closed.

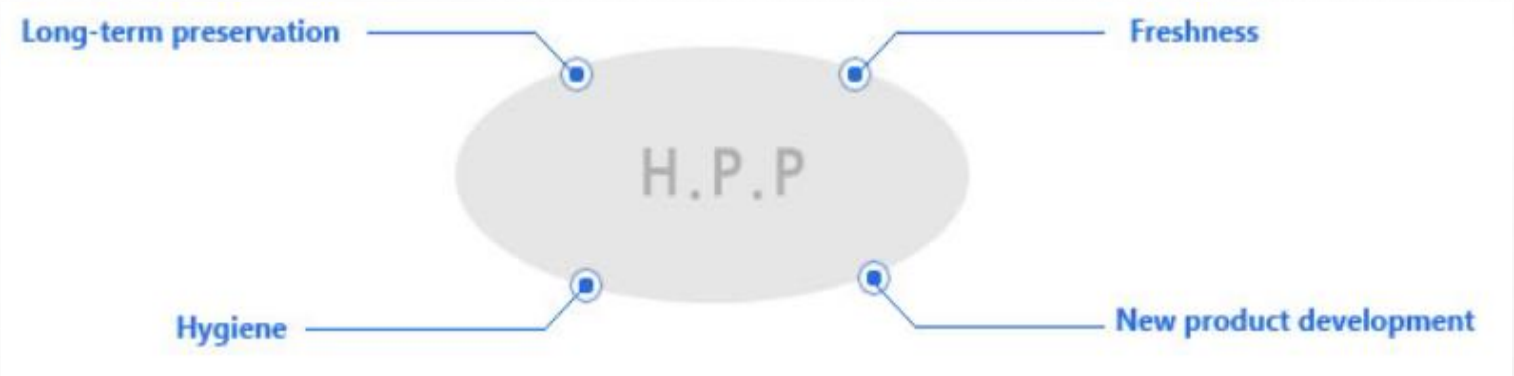
- The pressure medium usually water is pumped into the vessel from the bottom.

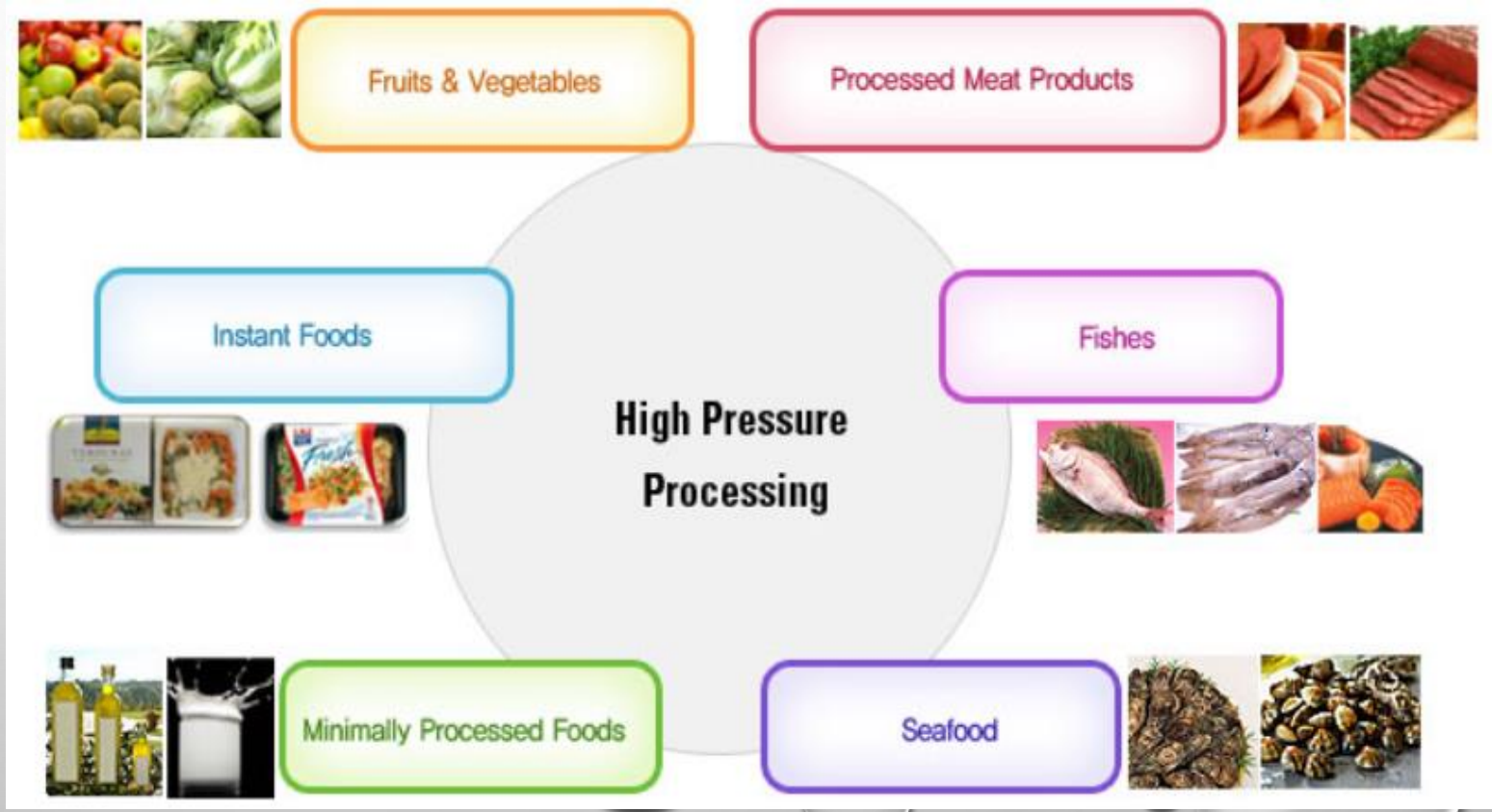
- Once the desired pressure is reached, the pumping is stopped, valves are closed, pressure can be maintained without further need for energy input.

Principle: A principle underlying HPP is that the high pressure is applied in an “isostatic” manner such that all regions of food experience a uniform pressure, unlike heat processing.

High Pressure Processing (HPP) is a cold pasteurization technique by which products, already sealed in its final package, are introduced into a vessel and subjected to a high level of isostatic pressure (300–600MPa / 43,500-87,000 psi) transmitted by water.

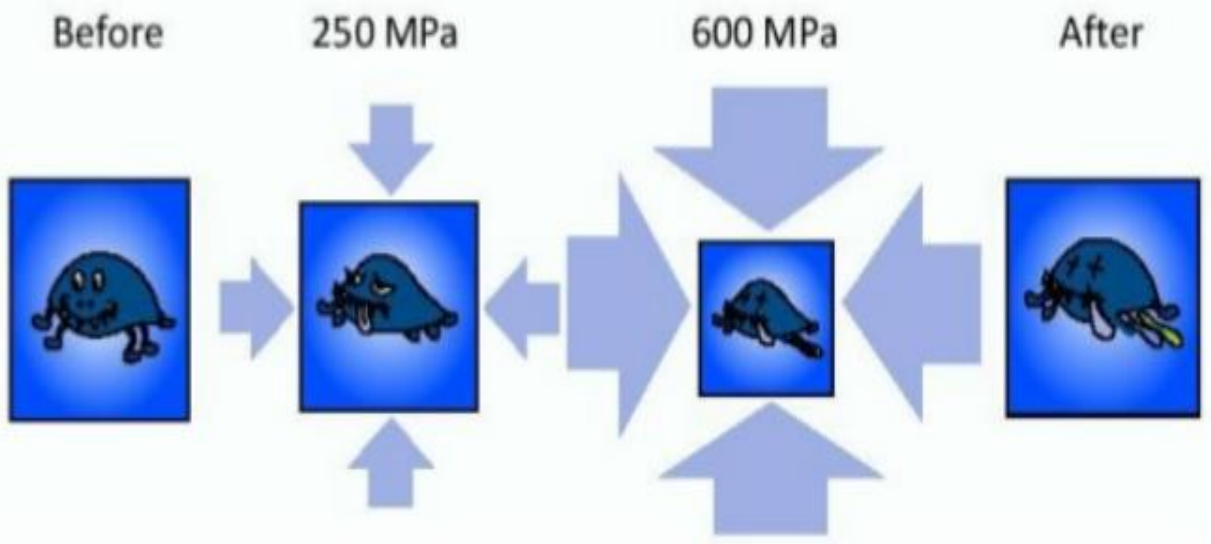




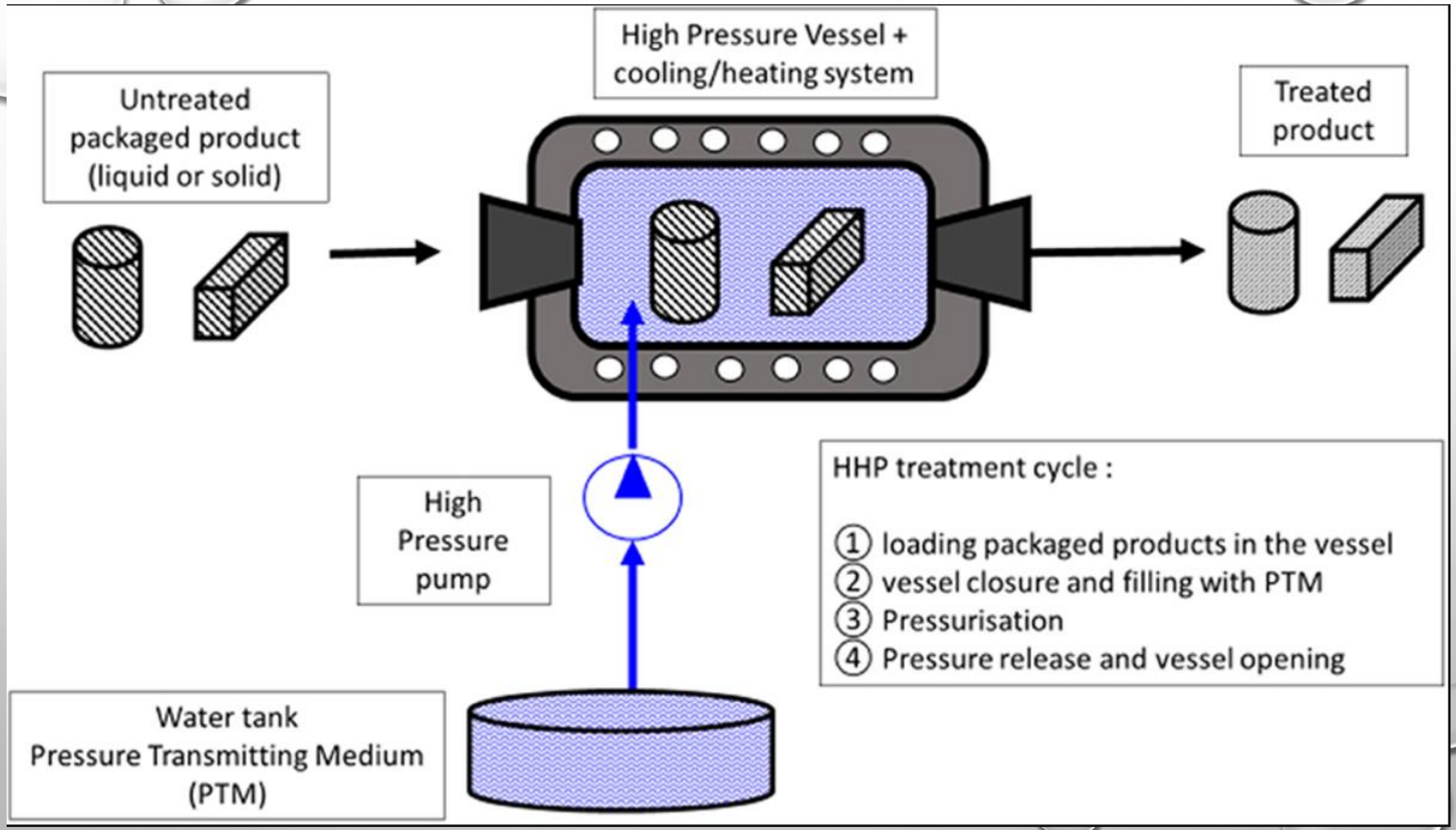


Features:

- Application of high pressures can cause:
  - Inactivation of Parasites, Plant cells.
  - Vegetative micro-organisms.
  - Some fungal spores.
  - Many food borne viruses.
  - Enzymes are selectively inactivated.
  - Macro molecules can change conformation.
  - Small molecules (eg: flavors) are generally unaffected
- High pressure is instantaneously and uniformly applied to the sample.
- Compression is fully reversible.



High pressure can kill microorganisms by interrupting their cellular function without the use of heat that can damage the taste, texture, and nutrition of the food.


High Pressure Vessel + cooling/heating system
Untreated packaged product (liquid or solid)
Treated product
High Pressure pump
HHP treatment cycle :
① loading packaged products in the vessel
② vessel closure and filling with PTM
③ Pressurisation
④ Pressure release and vessel opening
Water tank
Pressure Transmitting Medium (PTM)

How HPP Works?

Airtight/hermetically sealed packages are loaded into HPP carrier baskets.

Baskets are inserted into the HPP vessel. The vessel enters the system and is sealed by plugs.

Potable water is pumped into the vessel creating isostatic pressure (equal pressure all sides) on the packages.

Product is held at a pressure of 45,000 to 87,000 psi (310 to 600 Mpa) for 1 to 6 minutes depending on the HPP process recipe.

Pressure is transmitted uniformly & instantaneously throughout the product to disrupt microbial biochemistry of bacteria and spoilage microorganisms.

CONVEYOR

VESSEL

TO PACK OFF

EFFECT OF HPP ON MICROORGANISMS

- ✓ The primary site for pressure-induced microbial inactivation is the cell membrane.
- ✓ High pressure causes changes in cell morphology and biochemical reactions, protein denaturation and inhibition of genetic mechanisms.

Pressure required to achieve a 5-log cycle inactivation ratio for certain microorganisms for a 15 minute treatment

Microorganism	Pressure(Mpa)
Yersinia enterocolitica	275
salmonella typhimurium	350
Listeria monocytogens	375
Salmonella enteritidis	450
E. Coli O157:H7	680
Staphylococcus aureus	700

What is the effect of HPP on microorganisms?

In HPP operations, (400-600 Mpa) pressure is normally used for two minutes or greater.

High pressure applied to foods at room temperature will reduce numbers of most vegetative bacteria by up to 4 log units or greater and inactivate certain enzymes with only a small change in the organoleptic properties of the food.

Resistance of bacteria and other microorganisms to HPP is highly variable, e.g. some gram positive bacteria such as *Listeria monocytogenes* can exhibit higher resistance than gram negative bacteria such as *Salmonella*.

Spores of both bacteria and molds are largely resistant to inactivation by HPP.

Viruses have a wide range of pressure resistance, depending on their structural diversity. The effectiveness of HPP treatments will be dependent on the pressure applied, the holding time, temperature, the type of food matrix and the target organism.

Ultrasound

The definition of ultrasound / ultrasonic is the sound waves that have a higher frequency than the human ear can hear. An example of ultrasonic is an ultrasound image of an unborn baby.

Ultrasound is mechanical waves at a frequency exceeding the human hearing frequency which is about 20 kHz. It can be divided into three types: power ultrasound (16–100 kHz), high-frequency ultrasound (0.1–1 MHz) and diagnostic ultrasound (1–10 MHz). The sound waves resulting from the motion of continuous longitudinal waves when sound travels through a medium can generate the alternate compression and rarefaction of the particles in the medium and the consequent collapse of the bubbles causing cavitation. The cavitation produced by ultrasound can cause a rapid rise in temperature up to 5500 °C and increase the pressure up to 50 MPa and is therefore used to accelerate mass transfer, break down and dislodge particles, destroy the cell membrane or even change the structure of compounds. The different ultrasound systems frequency and energy density can be utilized for a different range of food application, food processing such as freezing, defoaming, filtration and emulsification, drying, Crystallization of fats, sugars, food preservation (inactivation of microorganisms and enzymes) and extraction of active ingredients from the food stuffs.

Ultrasound: what does it mean?

- Ultrasound is a cyclic sound pressure wave.
- Its frequency greater than the upper limit of human hearing.
- Beyond this frequency we talk about ultrasound range (freq > 20kHz).

- Ultrasound waves are similar to sound waves but, having a frequency above 16 kHz, cannot be detected by the human ear.
- Ultrasound refers to sound waves, mechanical vibrations, which propagate through solids, liquids and gases with a frequency greater than the upper limit of human hearing.
- Use of ultrasound in food processing includes extraction, drying, crystallization, filtration, defoaming, homogenization and also use of ultrasound as preservation technique.
- The principle aim of this technology is to reduce the processing time, save energy and improve the shelf life and quality of food products.

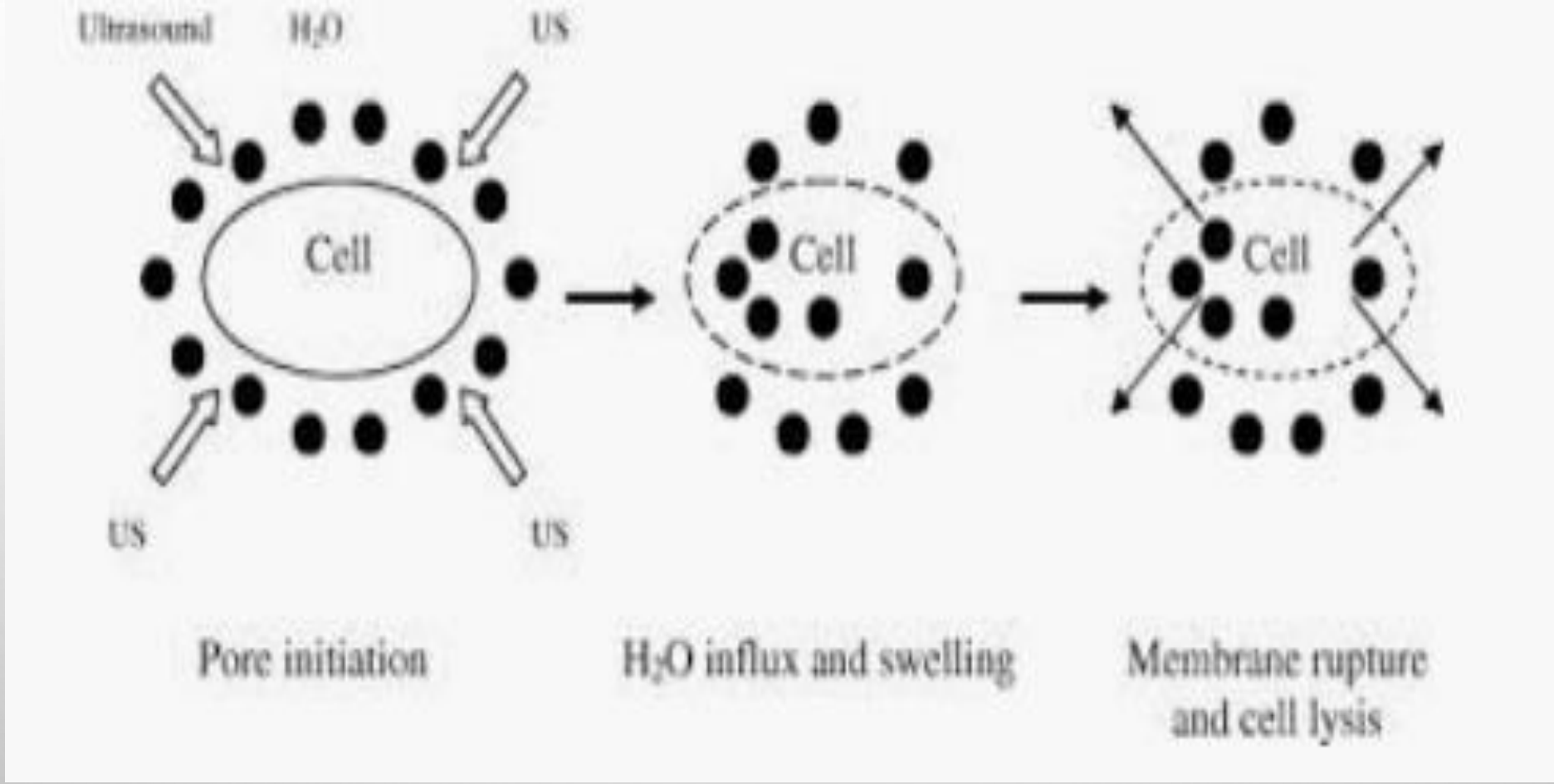
Microorganism Inactivation

During the cavitation process it changes the pressure and temperature cause break down of cell walls, disruption and thinning of cell membranes and DNA will be damage. Different kinds of microorganisms have different membrane structure. Gram-positive bacteria have a thicker cell wall and Gram- negative bacteria have a thinner cell wall. The rupture between the membrane and cell wall results in leakage of nutrients into the cell resulted in the death of microorganism.

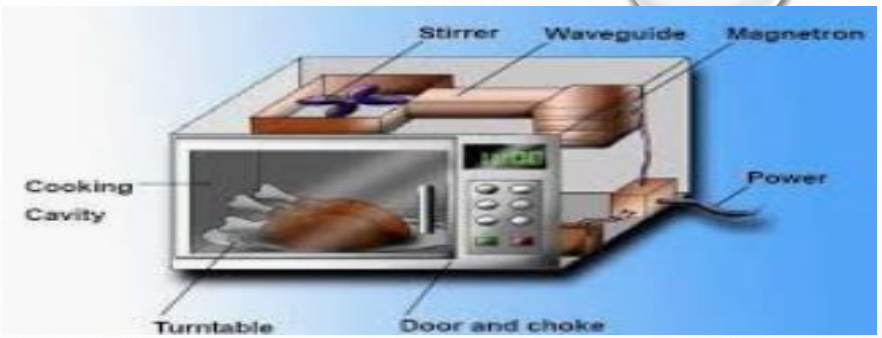
Factors affecting the effectiveness of microbial inactivation are

- ✓ Amplitude of ultrasound waves.
- ✓ Exposure or contact time.
- ✓ Volume of food processed.
- ✓ Treatment temperature.

The endospores of Bacillus and Clostridium species are very resistant to extreme conditions. Mano sonication treatment at 500kPa for 12min inactivated over 99% of the spores.


Ultrasound
H_2O
US
Cell
US
US
Cell
Cell
Pore initiation
H_2O influx and swelling
Membrane rupture
and cell lysis

Oscillating magnetic field



Introduction

Oscillating magnetic field has the potential to inactivate microorganisms and improves the quality and shelf life compared to other conventional process use for food preservation. It effects the microorganisms cell membranes as well as the malignant cells. Oscillating magnetic field of intensity of 5 to 50 telsa (T) and frequency of 5 to 500 kHz is generally applied in the process and reduced the number of microorganisms by at least 2-log cycles.

Magnetic fields are usually generated by supplying current to electric coils and the required magnetic flux densities of 5 to 50 telsa (T) is must for the inactivation of microorganisms. The technological advantage of inactivating microorganisms with OMFs include, minimal thermal denaturation of nutritional and organoleptic properties. Reduced energy level is required for adequate processing. Potential treatment of foods inside a flexible film package can be done to avoid post process contamination. Still, some additional research is necessary to conduct for correlating the inactivation of microorganisms in food and intensity used.

A number of reports showed the effects of magnetic field on microbial growth and reproduction as

i) Inhibitory,
ii) Stimulatory, and
iii) none observable.

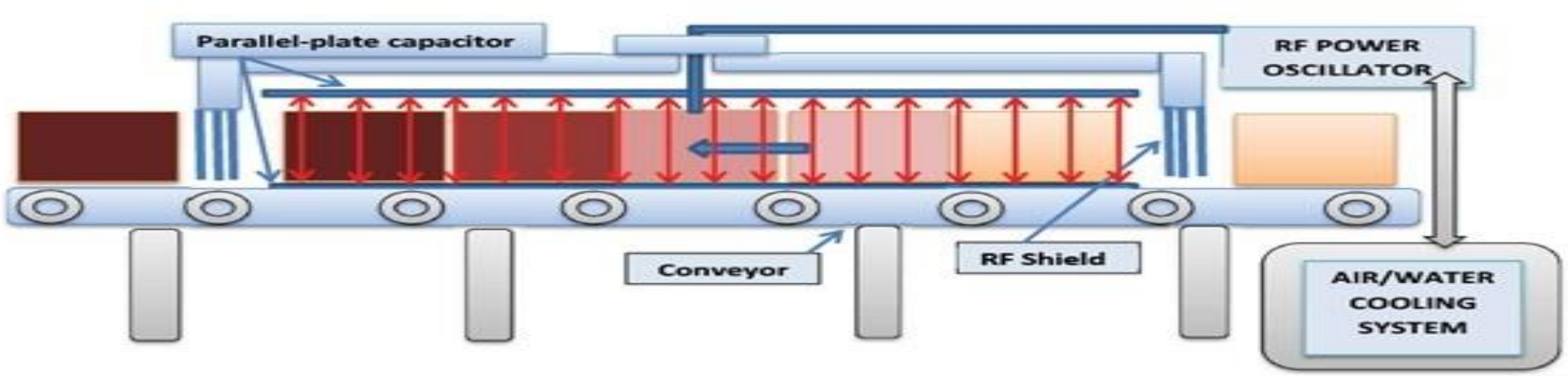
Inactivation of microorganism was observed in a number of research papers with Oscillating magnetic field specially in milk, yogurt, orange juice and bread roll and one pulse of Oscillating magnetic field was found adequate to reduce the bacterial population between 102 and 103 cfu/g.

Mode of Action

1. Loosening bonds between ions and Protein
2. Damage to Calcium and Magnesium ions (tissues and organs)
3. Breakdown of Covalent bonds in DNA.
4. Magnetic Field: Stimulate or inhibit growth and reproduction of microorganism and High Intensity Magnetic Field (HIMF) affects membrane fluidity.

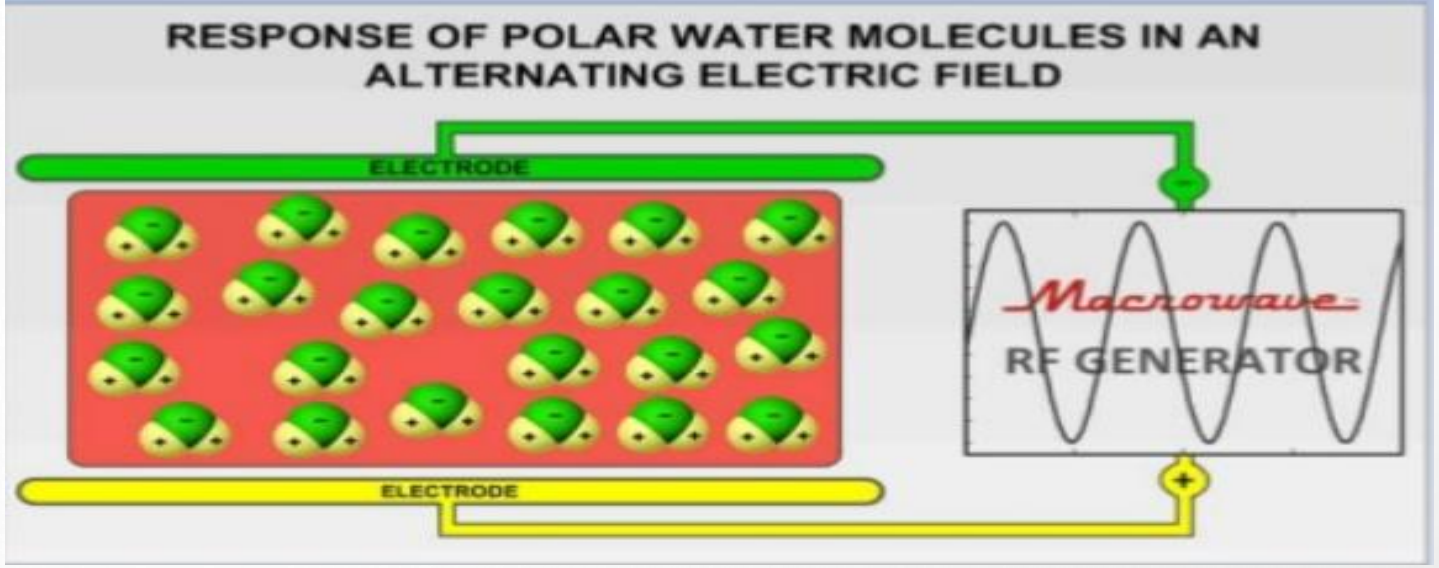
Radio frequency

Radio frequency (RF) heating is an advanced and emerging technology for food application. With the increasing demand for safe, hygienic, tastier, no fat and preservative free food in the world market this Radio frequency heating technology has gained an advantage in recent times. The main goal of all these novel technologies is to preserve our food by ensuring its safety and quality, which is a prime goal of food processing industry. Therefore, considering the consumer demand for high quality food and increasing processing cost involved in traditional methods, processors have started searching new alternatives.

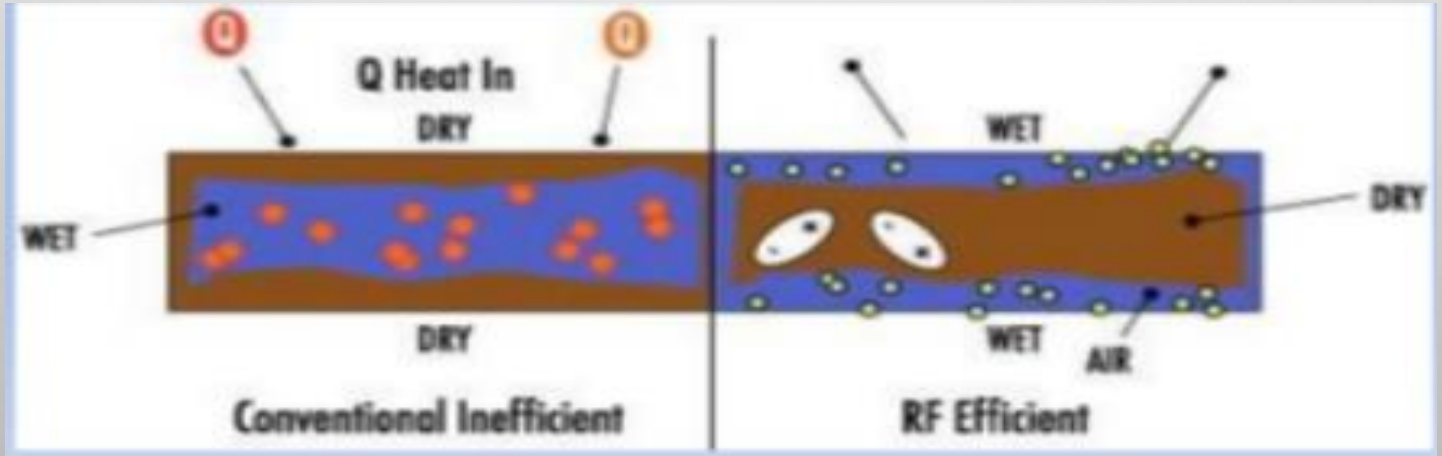


In this method electromagnetic energy transfers directly into the product resulted to induce volumetric heating due to frictional interaction between molecules. Heating of food is placed between two capacitor plates which plays the role of a dielectric where a high frequency alternating electric field is applied. Such field will force polar molecules (water) to constantly realign themselves with the electric field. Because of this the molecular movement is very fast due to the high frequency in the field. It will generate heat within the food by energy dissipation caused by molecular friction and inhibit microorganisms.

Radio frequency heating mechanism

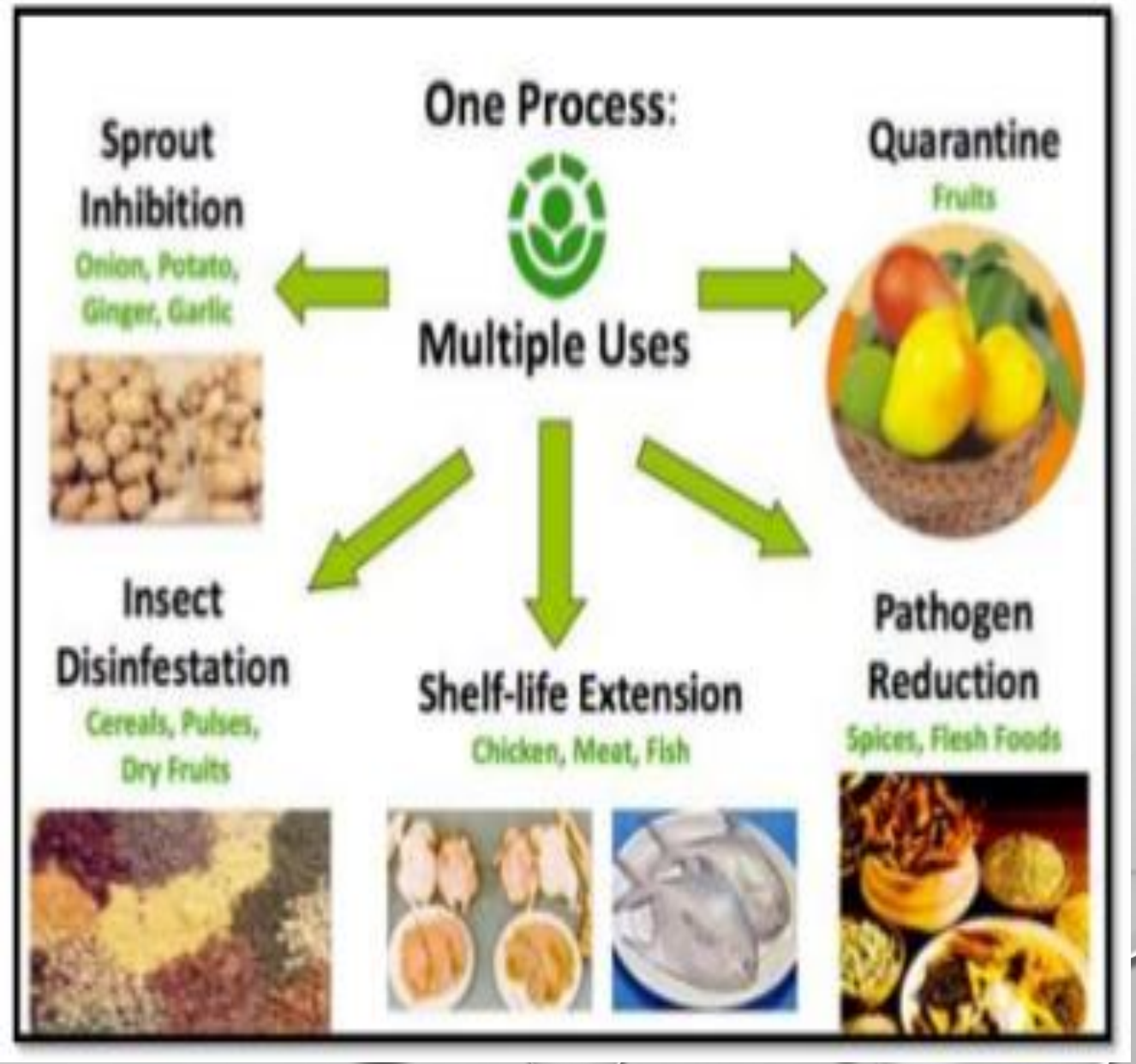


Radio frequency (RF) heating vs. conventional heating Conventional heating (i.e. conduction, convection, radiant) has a heat source on the outside. Heat is transferring to the surface of the material and then conducting the heat to the middle of the material. Radio Frequency heating is different; it heats at the molecular level. So it heats from within the material and heats the middle as well as the surface.



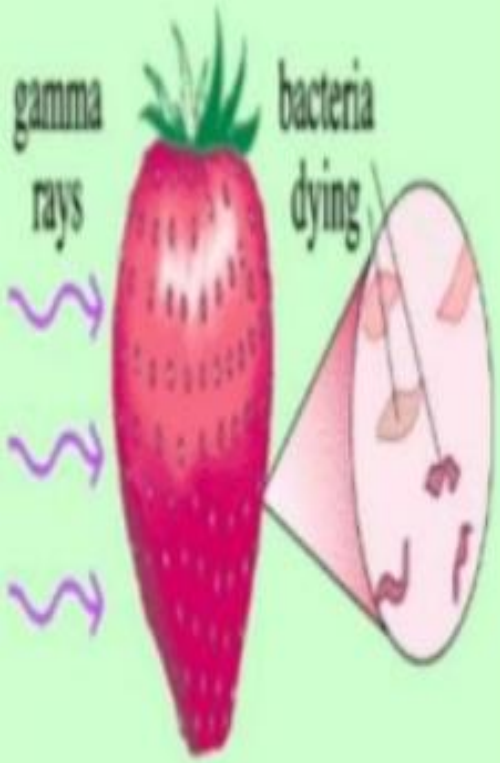
Food irradiation

Food irradiation (application of ionizing **radiation** to **food**) is a technology that improves the safety and extends the shelf life of **foods** by reducing or eliminating microorganisms. Like pasteurizing milk and canning fruits and vegetables, **irradiation** can make different **food** safer for the consumer.



What is Food Irradiation ?

"Process by which food is exposed to a controlled source of ionizing radiation to prolong shelf life, ***improve microbiologic safety***, and/or reduce the use of chemical fumigants and additives"



- exposing the food to the gamma rays of cobalt-60.
- The energy from the gamma ray passing through the food is enough to destroy many disease-causing bacteria as well as those that cause food to spoil, but is not strong enough to change the quality, flavor or texture of the food.

❑ Principles of Irradiation

- When ionizing radiation passes through a food product, some energy is absorbed by some chemical bonds.
- Some bonds rupture and produce free radicals which are highly reactive and unstable.
- They instantaneously rejoin with neighboring compounds and the results are called radiolysis compounds.
- These are similar to the compounds produced by heating (thermolytic compounds).
- The uniqueness of irradiation is that DNA (microorganisms and insects have a lot of DNA compared to plant cells) is very sensitive to irradiation.
- Irradiation of DNA at the approved levels causes base damage, breaking of DNA strands, and cross linking.
- All of these result in the loss of the organism's ability to reproduce

Mode of action ---

Radiation can cause both ionization and excitation and their absorption is not affected by structure of the molecule. Viruses, spores are resistant to radiation. Gram (-) spoilage bacteria more susceptible than pathogenic bacteria. *Clostridium botulinum* type E is resistant. Increase in mycotoxin was observed after irradiation. Affects microorganisms, such as bacteria, yeasts, and molds, causing lesions in the genetic material of the cell and effectively preventing it from carrying out the biological processes necessary for their existence. The principal targets of irradiation are nucleic acids and membrane lipids. It may act directly or indirectly.

Direct action: Every microorganism and living cell having target region which is radiation sensitive, a single ionization of radiation in this sensitive zone or region will kill the microorganism.

Indirect effect: Absorption of radiation by water, within or surrounding living cell produce free radicals. these are powerful oxidizing and reducing agent capable of damaging essential molecule and therefore causing death.

THANK YOU